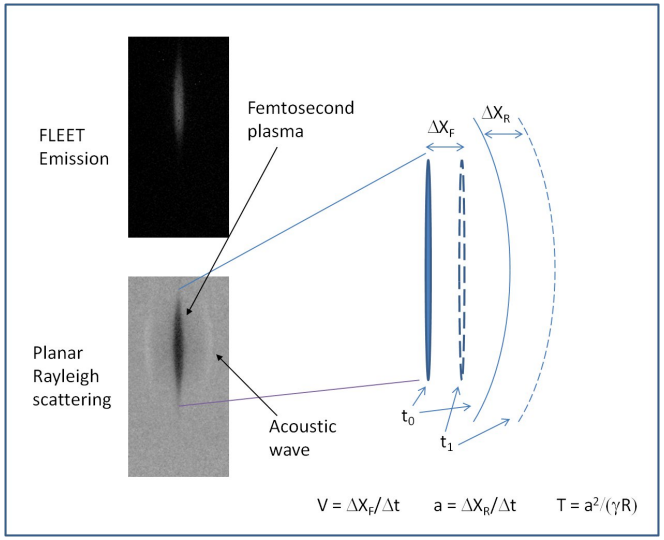
NASA SBIR/STTR Technologies

H7.02-9691 - Short Pulsed Laser Methods for Velocimetry and Thermometry in High Enthalpy Facilities

PI: Jacob George
MetroLaser, Inc. - Laguna Hills, CA

Identification and Significance of Innovation

A suite of laser-based diagnostics is proposed to measure velocity and temperature simultaneously using unseeded techniques in high enthalpy flows relevant to reentry flight. The two main types of regions that are found in a typical hypersonic flow field around a vehicle are addressed by developing separate diagnostics for each. In regions far from the body where the flow is mostly non-dissociated, femtosecond laser electronic excitation tagging (FLEET) is proposed for velocity combined with planar Rayleigh scattering to measure temperature. In the highly dissociated region near the stagnation point of the reentry body, either backward air lasing or radar REMPI will be applied to spectrally resolve a transition of atomic oxygen. The latter two techniques use the same two-photon excitation scheme, but backward air lasing relies on a population inversion induced in the measurement volume, and radar REMPI relies on the microwave interrogation of an induced plasma.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 6)

Technical Objectives and Work Plan

Technical Objectives:
1.For FLEET, determine a typical signal-to-noise ratio of the imaged laser line, and the corresponding error in the locating the line center.
2.For Rayleigh scatter imaging of the acoustic wave, determine the error in displacement as a function of laser intensity for a given optical setup.
3.For backward air lasing, determine the minimum oxygen or xenon atom concentration to produce a signal-to-noise ratio of 2.
4.For radar REMPI, determine the minimum oxygen or xenon atom concentration to produce a signal-to-noise ratio of 2.

Work Plan:
1.Kickoff Meeting
2.Measurement of velocity using FLEET
3.Evaluate the measurement of temperature using Rayleigh scattering in the presence of FLEET
4.Laser development
5.Radar REMPI experiments in a cell
6.Radar REMPI experiments in a burner
7.Potential for backward lasing at reentry conditions
8.Sensitivity limits for radar REMPI vs. backward lasing
9.Reporting

NASA Applications

NASA arc jet facilities, hypersonic wind tunnels, and shock tunnels would benefit. Non-intrusive measurements of velocity and temperature are required for validating computational fluid dynamic modeling and simulation codes that incorporate real-gas kinetic and transport models that are used to predict aerothermodynamics associated with planetary reentry flights. The diagnostics can be used as tools in experiments that focus on the understanding of high temperature gas physics and chemistry

Non-NASA Applications

The unique capability to measure temperature and velocity in high enthalpy flows will be attractive to the private space industry, including companies developing space launch systems for low Earth orbit and planetary exploration. In addition, the techniques developed herein can be used for combustion velocimetry and thermometry, e.g., measurements in premixed and diffusion flames.

Firm Contacts

Jacob George
MetroLaser, Inc.
22941 Mill Creek Drive
Laguna Hills, CA, 92653-1215
PHONE: (949) 553-0688
FAX: (949) 553-0495